Vol. 14(4) pp. 86-91, May 2020
DOI: 10.5897/AJFS2020.1912
Article Number: B43FB8363639
ISSN: 1996-0794

http://www.academicjournals.org/AJFS

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African Journal of Food Science

Full Length Research Paper

Influence of temperature and time on microbial, physicochemical and functional quality of goat milk

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Received 30 January, 2020; Accepted 2 April, 2020

Microbial load in fresh milk has a significant effect on its keeping quality and nutritional value. From Prehistoric time, human used heat process to reduce microbials load in raw milk to improve its sensory characteristics. This research is proposed to treat fresh goat milk with heating process to provide optimal pasteurization conditions that does not influence the goat milk chemical composition to suite production of goat yogurt powder. The pasteurization conditions considered were: Temperature (72, 80, and 85°C) and time (5, 10 and 15s). These results showed there were a significant difference (P<0.05) between treated milk and Indonesia national standards on viscosity and pH; whereas there was no significant differences on density and titratable acidity. The study results concluded that the temperature and time during heat processing had a significant effect on nutritional compounds of goat milk, with increase in lactose and non-fat solids contents; therefore, treated goat milk at 85°C to 5 s is better than other treatments.

Key words: Goat's milk, pasteurization, physicochemical analysis, microbiology.

INTRODUCTION

Milk is a good food in human diet. It is a source of nutrients such as vitamins, protein, fat, water, lactose, and essential minerals. It contains minerals, enzymes and vitamins as secondary constituents (Contreras et al., 2015; Raikos, 2010; Pereira, 2014; Mcmahon, 2013; Guetouache et al., 2014).

Goat's milk contains a higher amount of minerals than cow and human milks, such as magnesium, calcium and phosphorus (Abbas et al., 2014). Moreover, itcontains several nutrients and therapeutic properties as a functional diet for human health. It's important for prevention of diseases, and used for stimulation of immunity (Vargas et al., 2008; Zenebe et al., 2014; Kumar et al., 2012).. Goat's milk has a higher digestibility and less sensitivity digestion than cow's milk, as well as a higher content of short-chain fatty acids in milk fat, high zinc and iron content magnesium and antibacterial properties (Slacanac et al., 2010; Guowei et al., 2016). Microbial growth has been reported to impact negatively on the physicochemical characteristics, shelf life of raw and processed milk as well as in other dairy products (Samaržija et al., 2010). Heat processing is the oldest

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methods used to treat dairy products; it is applied to reduce microbial load in raw milk and improving sensory properties of milk compounds. Thus, it is consideredas a very effective and simple method. In addition, it has a positive effect on sensory and nutritional values of milks and dairy products (Pedras et al., 2012; Raikos, 2010; Vargas, 2016).

The high temperature for long time processing of milk leads to more reduction of the amount of water, leading to increase in total solids. Moreover, heat treatment of milk up to 80°C for 15sleads to less nutritional minerals such as calcium (Sestan et al., 2016). Pasteurization is capable of reducing a count of microbial load in raw milk, which is important to extend the shelf life of milk. On the other hand, they have no influence on milk composition and fatty acid profile (Pestana et al., 2015; El-Zubeir et al., 2007).

Pasteurization is one of the processing used to reduce microbial load and extend the shelf life of the milk. However, it affects milk compounds and decreasesthe milk nutritional values. It has negative effect on loss of some vitamins with changing in nutritional and sensory properties (Cavalcante et al., 2013; Aguirre et al., 2009; Abd Elrahman et al., 2013). The study investigated the effect of pasteurization temperature and time on microbial and physicochemical quality of goat's milk and its outcome on lactose and non-fat solids level.

MATERIALS AND METHODS

Sample collacted

Goat's milk samples,Perankan Etawa, were purchased from Baturaden Animal Farm, Purwokertow, Central Java, Indonesia. Then samples were stored in freezer at -80°C for subsequent processing.

Heat processing

A half liter (500ml) for each goatmilk samples were weighted and put separately in a pot.Milk samples were coded from Y1 to Y9 as treated milk and Y10 as a control. Milk samples were put in pots and heated at different temparetures (72, 80 and 85°C) at different times (5, 10 and 15 s). The milk samples were treated according to methods (Zhao, 2016; Miao, 2011; Wu et al., 2016; Ibrahim et al., 2019).

Physicochemical analysis

The goat milk samples were analyzed for the chemical compositions using a lactoscan analyzer. The compositional parameters evaluated were: Physical and chemicalcharacteristics of heated milk as (total solid (TS), pH, titratable acidity (TA), density (25°C), viscosity (25°C), and color. The density was determined according to (SNI: 06- 2385-2006), official method 920.212. The viscosity was determined according to AOAC (2005). The color parameters were determined using a minolta CM-2002 spectrophotometer (minolta camera Co., osaka, Japan) in the reflection mode, using the method of (Chugh et al., 2014; Bermúdez-Aguirre et al., 2009), according to color meassured. Lightness to darkness (L*) (100 to 0), redness(+) to greenness (-)(a*) and yellowness (+) to blueness (-)(b*) 20 ml of raw and thermo-ultrasonicated.The total solid (TS) was determined according to the method of Almeida et al. (2010). The pH (AOAC, 2005) and the titratable acidity (TA) was determined according to AOAC (2005) method.The microbiology analysis of the samples, total plat count, yeasts, and moulds were determined according to method of Mohammad and El-Zubeir, (2011) as decribed by Igbabul et al. (2014). The media and distilled water and other tools were sterilized using autoclave, and using serial dilution to 10^3 to reduce the number of microorganisms in samples.

Statistical analysis

The analysis of variance (ANOVA) two-way tests was performed to evaluate the difference between data by using SPSS for Windows (version 16, SPSS, Inc., Chicago, IL) and Microsoft Excel (2013). The means were separated by Duncan Multiple range test. Significant differences were determined at ($P \leq 0.05$).

RESULTS AND DISCUSSION

Goat milk compositions

The results obtained from Table 1 shown compositions content of fresh goat milk. Fresh goat milk sample analysis by lactoscan showed that the fat content was 6.67%. This result shows that fresh goat milk has a higher fat content than cow milk; thus, it has better taste and aroma in final yogurt production. This result agrees with Indonesian National Standards (2008), and disagrees with Yusa et al. (2017), who reported that the fresh goat milk fat content wes 4.5% and pasteurized goat milk was 5%. This difference in fat contentt is due to animal type, age, race, season, environment and feeds. Specific gravity value was 21.41%; this result is lower than cow milk specific gravity. These results showed significant difference with Standard National Indonesian (SNI) (2011) in specific gravity, this difference is due to water content in milk. The high amount of water in milk decrease specific gravity and other milk compositions. The non-fat solids values were 6.81%, this result is lowest in cow milk having non-fat solids, and disagrees with TAS (2008). The lactose value obtained was 3.26%, this result showed that the lactose content of fresh goat milk is lower that cow milk and not in range of standards. TAS (2008) it reported the lactose content of milk was minimum 4.5% and non-fat solids was 7.8%; this difference is due to animal type, age, race, season, environment and feeding.

Effect of pasteurization on fresh goat milk compositions

The protein results showed that in Table 2, from these results obtained, the protein content (%) of sample Y1

Table 1. Goat milk compositions.

Parameter	Values (%)
Fat	6.67
Specific gravity	21.41
Lactose	3.26
Non-fat solids	6.81
Protein	3.22
Added water to milk	25.54
Freezing point	-0.384

Table 2. Effect of pasteurization on goat milk compositions.

Parameter	Fat	Specific gravity	Lactose	Solids non-fat	Protein
Y1	6.65^{a}	22.49^{c}	3.89^{b}	7.10^{b}	2.97^{a}
Y2	6.47^{ab}	25.33^{ab}	4.19^{ab}	7.65^{ab}	2.89^{ab}
Y3	5.57^{d}	24.78^{ab}	4.41^{a}	8.06^{a}	2.61^{b}
Y4	6.21^{b}	25.43^{ab}	4.23^{ab}	7.73^{ab}	2.84^{ab}
Y5	6.02^{b}	26.40^{a}	4.36^{a}	7.98^{a}	2.68^{b}
Y6	5.73^{c}	23.44^{bc}	4.39^{a}	7.99^{a}	2.60^{b}
Y7	6.47^{ab}	25.96^{a}	4.31^{a}	7.84^{ab}	2.89^{ab}
Y8	5.96^{b}	24.52^{ab}	4.28^{ab}	7.85^{ab}	2.88^{ab}
Y9	5.75^{c}	25.57^{a}	4.29^{ab}	7.86^{a}	2.87^{ab}
Y10	6.67^{a}	21.41^{d}	3.26^{c}	6.81^{c}	3.22^{c}

Y1 = 72^{o} /5s, Y2 = 72^{o}C /10s, Y3 = 72^{o}C /15s,Y4 = 80^{o}C /5s,Y5 = 80^{o}C /10s, Y6 = 80^{o}C /15s, Y7 = 85/5s, Y8 = 85/10s, Y9 = /15s, and Y10 as control.

was 2.97 is higher than other samples, and protein value in sample Y6 was 2.59, which is lowest in protein content. The results obtained from each samples showed significant difference with control sample and SNI (2011), which reported that the goat milk protein contains between 3.1-3.2, fat contain is 3.25-3.5, and total solid is 11.7-12. This difference is due to temperature and time, which have significant effect on decreased fresh goat milk protein level. This decrease in level of protein with increase pasteurization temperature is due to concomitant decrease in moisture, hence the increase in level of protein denaturation. These results are consistentwith Hamodah et al. (2018), Aguirre et al.(2009) but disagrees with Abdelrahman et al. (2013), who mentioned that pasteurizing milk can decrease nutritional values of milk such as protien content, pH and density. Also, from the results, it increase the butter fat and titratable acidity in milk, and this is in agreement with Ul Hag et al. (2013), who mentioned that pasteurization and sterillization processes revealed significant influence on pH, titeritable acidity, specific gravity, lactose, fat, protein and ash content of milk and skimmed milk.

The fat content was higher in Sample Y1, 6.65%and lowest in Y3,5.57%. This result showed that fat content is lower than control and higher than indonesian national standard.From these results, the pasteurization has significant effect on decrease fat content of fresh goat milk. This decreasein fat content is due to effect of pasteurization temperature on oxidation of milk fat; thus, leading to breaking up of the clumps or clusters of fat in raw milk, and consequently, decrease fat content in treated milk. These results are in agreement with Elhasan et al. (2017), Mohammad et al. (2017), and disagrees with Li et al (2018), who mentioned that pasteurization treatment is capable to reduce microbila load in fresh milk.However, it is not effective on levels of oxidation in lipids and without significant changes in the milk pH. This is in agreement with some studies (Cavalcante et al., 2013; Aguirrre et al., 2009; Abd Elrahman et al., 2013) that reported that Pasteurization is one of the treatments used to reduce microbial load and prolong the shelf life of raw milk. it has positive effect on milk compounds and decrease nutritional values of milk. However, it has loss of some vitamins with change in nutritional and sensory properties.

The non-fat solids are highest in Y3 sample was 8.06%, and showed lowest in sample Y1, 7.1%. From these results, there were significant difference (P≥0.05) between all treated milk samples with control. This results shows that pasteurization has significant effect on

Table 3. Physicochemical properties of pasteurized goat milk.

Parameter	Density	pH	Titeritable acidity	Freezing point
Y1	1.03[b]	6.6[a]	0.10[a]	-0.4605[ab]
Y2	1.03[b]	6.5[a]	0.12[a]	-0.493[abcd]
Y3	1.05[bc]	6.4[a]	0.11[a]	-0.539d
Y4	1.08[a]	6.3[b]	0.10[a]	-0.501 [abcd]
Y5	1.03[b]	6.3[b]	0.11[a]	0.5195[cd]
Y6	1.04[bc]	6.2[c]	0.11[a]	-0.452[a]
Y7	1.06[d]	6.6[a]	0.10[a]	-0.51[bcd]
Y8	1.05[bc]	6.5[a]	0.11[a]	-0.48[abc]
Y9	1.06[d]	6.4[a]	0.11[a]	-0.511[cd]
Y10	1.03[b]	6.7[a]	0.10[a]	-0.384[e]

Y1 = 72°C /5 s, Y2 = 7°C /10 s, Y3 = 72°C /15 s,Y4 = 80°C /5 s,Y5 = 80°C /10 s, Y6 = 80°C /15 s,Y7 = 85/5 s, Y8 = 85/10 s, Y9 = /15 s, and Y10 as control.

increased non-fat solids. This differencein increasing non-fat solid due to the temperature effect on evaporated water from milk led todecreased water content, and change in nature of carbhydrate in milk. These results disagree with Abdelrahman et al. (2013), who mentioned that pasteurizing milk can decrease nutritional values of milk such as protein content. On the other hand, lactose content and specific gravity in each samples increased.In addition, the heat treatment increased non-fat olids, lactose and specific gravity values, and deceased the protein and fat content. This results is consistent with Hamodah et al. (2018) and Aguirre et al. (2009) and disagree with Abdelrahman et al. (2013), who mentioned that pasteurizing milk can decrease nutritional values of milk such as protien content, pH. Also, it increased the titratable acidity in milk, which is in agreement with Ul Hag et al. (2013) who mentioned that pasteurization and sterillization processes revealed significant influence on pH, titeritable acidity, specific gravity, lactose, fat protein and ash content of milk.

Effect of heat processing on physicochemical properties of fresh goat milk

Table 3 showed effect of pasteurization on physical and chemical properties of fresh goat milk. The results obtained are presented in Table 3. Based on results obtained from milk analysis by lactoscan analyzer,it showed that the pH of Y1 was 6.6, Y2 was 6.5, Y3was 6.4, Y4 was 6.3, Y5 was 6.3, Y6 was 6.2, Y7 was6.6, Y8 was 6.4, and Y9 was 6.5. These results showed that the pH of Y3 is higher comparedto other samples, and pH values of Y6 sample was lowest, 6.2. From these results there was significant diference between heated goat milk and control. These results shows that pasteurization has significant effect on decreased pH value of fresh milk. The difference in pH value is due to effect of temperature and time on milk compounds. The density values of samples were 1.03, 1.03, 1.05, 1.08, 1.01, 1.04, 1.06, 1.05, 1.06 respectivly. The result obtained shows that the density of Y4 is highest, and density value of Y5 sample is the lowest. These results showsignificant difference (P≤ 0.05) between Y4, Y9, Y7, Y8, Y3 and Y5;on the other hand, no significant difference (P≤ 0.05) between Y1Y2 and control samples. The freeze point values were -0.460, -0.493, -0.539, -0.501, -0.519, -0.452, -0.510, -0.480, -0.511, and -0.384 as control samplerespectively. These results showed significant difference (P≤ 0.05) between heat goat milk samples. These results indicate that the pasteurization has significant effect on pH decrease, density and freezing point, and increase of titeritable acidity in goat milk. Conversely, there was no significant effect on titeritable acidity. This result disagrees with Frau et al. (2014), and agrees others (Ul Hag et al.,2013; Elhasan et al.,2017). Wang et al. (2016) reported the different heat processes effect on milk properties, and agrees with Ul Saha and Ara (2012), who mentioned that pasteurization and sterillization processes revealed significant influence on pH, titeritable acidity, specific gravity, lactose, fat protein and ash content of milk and skemmed milk.

Effect of pasteurization on micorobial load in goat milk

According to Table 4, the tpc values ($x10^3$cfu/ml) were 8.6, 7.0, 6.0, 6.0, 5,3 5.3, 4.6, 4.4, 3.6 and 12.1 as control sample respectivly. The results showed significant difference (P≤ 0.05) between each sample. The values of yeast were 5.0, 4.0, 3.3, 2.3, 2.3, 2.3, 1.3, 2.0, 2.3 and 7.5 respectively. Significant difference (P≤ 0.05) between Y1, Y2, Y3, Y7, Y8, and control was seen. Moreover, no significant difference was seen between Y4, Y5, Y6 and Y9. The amount of microbials loded in raw milk was reduced by all treatment types of pasteurization. On the other hand, 80°C for 15 min of pasteurization reduced the amount of total plate count, yeast and mould compared to control 12.1 - 3.6, 7.5 - 2.3, 10.0 - 3.3 $\times10^3$ cfu/ml

Table 4. Micorobiology analysis of heated goat milk.

Parameter	TPC10^3cfu/m/	Yeast	Mould
Y1	8.6^a	5.0^a	4.3^a
Y2	7.0^b	4.0^{ab}	4.0^a
Y3	6.0^c	3.3^b	3.3^a
Y4	6.0^c	2.3^{bc}	5.3^a
Y5	5.3^d	2.3^d	5.0^a
Y6	5.3^d	2.3^d	3.6^a
Y7	4.6^e	1.3^f	4.3^a
Y8	4.4^e	2.0^e	5.0^a
Y9	3.6^f	2.3^d	3.3^a
Y10	12.1^g	7.5^g	10.0^b

respectively. Therefore, the microbiological results highlighted that pasteurization was effective to reduce microbial loadin milk. Moreover, the pasteurizing milk at different temperature for different times such as 72, 80 and 85°C for 5, 10 and 15s were effective to decrease count of microbials in milk.These reductions are possibly enough to improve the quality of raw milk, thus increase quality of products made from it. These results are in agree with Cavalcant et al. (2013). SNI (2011) set the microbial contamination in fresh milk at a maximum limit of Enterobacteriaceae consisting 1×10^3cfu/ml and *Staphylococcus aureus* of 1×10^2 cfuL. The total plate count (TPC) has a maximum 1×10^6cfu/ml. In addition, the pasteurization at 85°Cfor 15sis capable of reducing microbial load in raw milk;however, most heat fresh goat milk at higher temperature to shorten time such as 85°C to 5s or 72°C for 15s.

Conclusion

This study concludes that temperature and time has significant ($P\leq 0.05$) effect on goat milk chemical composition such as lactose, protein, fat, non-fat solids contents and physicochemical properties such as pH, density, and freezing point. Onthe other hand, it decreases protein, fat, pH, and density, whileit increases the lactose and non-fat solids of goat milk.Therefore, the 85°C for 5sincreased the level of non-solids and lactose in goat milk issuitable for producing goat milk yogurt powder.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

The authors are grateful to the ministry of research, technology and higher education, and to the Research and Society Service Institute of Universitas Genderal Soedirman for their funding and support. They also want to thank Omdurman Islamic university for the collaboration.

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